

PSYCHE

A JOURNAL OF ENTOMOLOGY

ESTABLISHED IN 1874

VOL. XLVI

MARCH, 1939

No. 1



TABLE OF CONTENTS

A Simple Stroboscopic Method for the Study of Insect Flight. <i>Leigh E. Chadwick</i>	1
Immature North American Trichoptera. <i>Margery J. Milne</i>	9
The Mimetic Resemblance of Flies of the Genus <i>Systropus</i> to Wasps. <i>Charles T. Brues</i>	20
Some Extracts from the History of Entomology in China. <i>Gaines Liu</i>	23
Further Notes on Cannibalism Among Larvae. <i>V. G. Dethier</i>	29
Additional Records of Onychophora from the Island of Haiti. <i>Charles T. Brues</i>	36
On the Genus <i>Abaris</i> Dej. (Coleoptera: Carabidae). <i>S. L. Straneo</i>	38

CAMBRIDGE ENTOMOLOGICAL CLUB

OFFICERS FOR 1938-1939

<i>President</i>	.	.	.	.	.	.	W. S. CREIGHTON
<i>Vice-President</i>	.	.	.	.	.	.	C. H. BLAKE
<i>Secretary</i>	.	.	.	.	.	.	V. G. DETHIER
<i>Treasurer</i>	.	.	.	.	.	.	RICHARD DOW
<i>Executive Committee</i>	{	.	.	.	.	.	F. M. CARPENTER
		.	.	.	.	.	C. H. BLAKE
		.	.	.	.	.	C. A. FROST

EDITORIAL BOARD OF PSYCHE

EDITOR-IN-CHIEF

C. T. BRUES, HARVARD UNIVERSITY

ASSOCIATE EDITOR

F. M. CARPENTER, HARVARD UNIVERSITY

CONSULTING EDITORS

NATHAN BANKS,
Harvard University.

A. E. EMERSON,
University of Chicago.

THOMAS BARBOUR,
Harvard University.

A. L. MELANDER,
College of the
City of New York.

RICHARD DOW,
New England Museum of
Natural History,
Boston, Mass.

J. G. NEEDHAM,
Cornell University.

PSYCHE is published quarterly, the issues appearing in March, June, September, and December. Subscription price, per year, payable in advance: \$2.00 to Subscribers in the United States; foreign postage, 25 cents extra, Canada 15 cents. Single copies, 65 cents.

Cheques and remittances should be addressed to Treasurer, Cambridge Entomological Club, Biological Laboratories, Harvard University, Cambridge, Mass.

Orders for back volumes, missing numbers, notices of change of address, etc., should be sent to Professor F. M. Carpenter, Biological Laboratories, Harvard University, Cambridge, Mass.

IMPORTANT NOTICE TO CONTRIBUTORS

Manuscripts intended for publication, books intended for review, and other editorial matter, should be addressed to Professor C. T. Brues, Biological Laboratories, Harvard University, Cambridge, Mass.

Authors contributing articles over 8 printed pages in length will be required to bear a part of the extra expense, for additional pages. This expense will be that of typesetting only, which is about \$2.00 per page. The actual cost of preparing cuts for all illustrations must be borne by contributors; the expense for full page plates from line drawings is approximately \$5.00 each, and for full page half-tones, \$7.50 each; smaller sizes in proportion.

AUTHOR'S SEPARATES

Reprints of articles may be secured by authors, if they are ordered before, or at the time proofs are received for corrections. The cost of these will be furnished by the Editor on application.

Printed by the Eliot Press Inc., Jamaica Plain, Mass., U. S. A.

PSYCHE

A Journal of Entomology

Volume XLVI

1939

EDITED BY CHARLES T. BRUES

Published by the Cambridge Entomological Club
Biological Laboratories
Harvard University
Cambridge, Mass., U. S. A.

PSYCHE

VOL. XLVI

MARCH, 1939

No. 1

A SIMPLE STROBOSCOPIC METHOD FOR THE STUDY OF INSECT FLIGHT

BY LEIGH E. CHADWICK

Biological Laboratories, Harvard University

The methods which have been used for the study of insect wing motion may be reduced for purposes of comparison to six types. Briefly these are (1) the deductive method, (2) the acoustic method, (3) the visual or optical method, (4) the graphic method, (5) the photographic method, and (6) the stroboscopic method. A short discussion of them and of the sort of information they have yielded will be useful in judging the possibilities of the new application of the stroboscopic method outlined below. Further details and references may be found in the works of Prochnow (1924), Weber (1933), Magnan (1934) and Snodgrass (1935).

The deductive method is essentially that of the earlier anatomists. Supplemented by manipulation of dead or anæsthetized specimens it is still useful in studying the more intimate mechanism of the thorax. It cannot be expected to give exact information as to the actual motions of the wings in flight, nor *a fortiori* as to their rate.

The principle employed in the acoustic method is to match the insect's *Flugton* with the tone of a tuning fork or other instrument of known frequency. This method was applied extensively by Landois (1867) for rate determinations, but his results have not agreed too well with those obtained more directly with kymograph or camera. The relation between the pitch of an insect's tone and the frequency of its wing motion is still not completely understood, and in many cases

it appears likely that harmonics may be mistaken for the fundamental. For this reason, and because of difficulties thought to be introduced by the Doppler effect, not much attention has been given to this method by later workers.

The optical method of Wheatstone (1827) was applied by Marey (1868) to the study of wing motion. By gilding areas of the wing he was able to observe its trajectory in living insects held with forceps, and confirmed Pettigrew's (1868) deduction that the wing stroke follows the outline of a figure-8. The type of problem for which this method is suitable is illustrated further by the work of Stellwaag (1916), who was able thus to observe the differential action of the wings in steering. The method cannot be called on, however, for the sort of detail available so abundantly in a photograph, and has the further disadvantage that information gained from it must often pass through a stage of subjective interpretation before it reaches the record. It permits some degree of measurement of the various amplitudes of the wing motion, but affords no data as to rate.

Marey (1868) also introduced the use of the kymograph in the study of wing motion. This instrument gives a permanent non-subjective record, from which it is easy to calculate frequencies, but is limited in other directions. The wing of the insect, used as the recording lever, is of fixed radius, and its motion is complex. If undue friction is to be avoided, only a small fraction of the arc described by the wing tip may be recorded at one time. Insofar as frequency measurements are concerned, the results obtained by Marey and other students who have used the graphic method agree, on the whole, within the limits of normal variation with data derived from other techniques. The distortions bulk larger, however, where it is desired to achieve a true picture of the unhampered motion of the wing. Naturally the kymograph may be used only with fastened and not with freely flying insects.

A third technique introduced by Marey and in the development of which his followers have had a large share is that of high-speed photography. Theoretically this is the most advantageous method for the study of insect flight, but its application is difficult. The high rate at which the wings are moved, 150-250 beats per second being not uncommon

among the Diptera and Hymenoptera, fixes the length of exposure, and the duration between successive exposures for motion pictures, at exceedingly low limits. To obtain adequate illumination at such frequencies becomes a very real problem, which is intensified by the small size of many species. Added to the photographic difficulties are those of posing the often unwilling specimens. Under these conditions, the method proves expensive in time, film and apparatus,—yet the results which it promises serve amply to justify continued efforts toward its perfection. The extent to which the obstacles mentioned have been overcome at present may be gauged by reference to the fine reproductions in Magnan (1934).

With the more evident merits and disadvantages of these several methods in mind, we may proceed to discuss the stroboscopic technique. The stroboscopic principle has been the basis of most of the attempts at high-speed photography, but Oehmichen (1920) appears to have been the only worker who has previously made much use of the stroboscope for the visual study of insect flight. With the stroboscope, cyclic motions may be made to seem to stand still (and to proceed slowly forward or in reverse) no matter what the actual frequency may be. All that is necessary is an intermittent source of light tuned to synchrony (or near synchrony) with the motion to be observed. In Oehmichen's apparatus light was provided by electric discharge across a spark gap or through a Geissler tube. Frequency could be synchronized automatically with that of the wings by an ingenious arrangement which allowed air currents produced by the wing to open a very light key in the primary circuit at a given phase in each beat. If a variable control of frequency was desired, this key was replaced by a rotary interruptor, the speed of which was regulated by a potentiometer. With this apparatus Oehmichen made visual and photographic observations of much interest, but neither his results nor his method have received much attention since their publication.

The recent development of the Edgerton stroboscope (Germeshausen and Edgerton, 1937) should give a new impetus to studies along this line. Earlier stroboscopes have suffered from shortcomings, either in regard to the source of

light, which was not dependable, or in regard to control of the frequency, which was unwieldy because of rotational inertia, etc. No difficulties of this sort are met with in the instrument under discussion, in which the flash-frequency of a neon or other low-pressure-filled bulb is controllable instantly by an adjustable electric oscillator. The instrument as supplied operates on 110 V 60-cycle AC, and gives direct scale readings in RPM over a range of 600–14,400 cycles per minute (10–240 per second). Values above and below these limits may be calculated easily from harmonic relationships. The accuracy is within $\pm 1.0\%$ over the full range.

The motion of an insect's wings is fundamentally a cyclic phenomenon, and may therefore be studied by this means. In theory one may place any flying insect before the instrument and by suitable tuning either "stop" the wings completely at any phase in the cycle or permit the cycle to proceed slowly through its several phases while observations are made. How fully these desired conditions may be attained in practise varies considerably with different insects, but, given appropriate treatment of the specimens, the theoretical expectations may be realized very satisfactorily.

Rates may be determined quickly and easily.

Study of the complex motions of the wings is more exacting. Here results depend partly on the operator's patience, since the problem is largely one of inducing the specimens to fly steadily and for longer intervals. Favorable responses can be had in the majority of cases, and are well worth the effort, for the details of the wing motion are displayed with a clarity that is far beyond that of any photographs so far published.

The most evident disadvantage of the method is that, like other visual techniques, it gives no permanent record beyond the notes of the observer. In respect of rate determinations, this objection is less forceful, since one simply tunes to synchrony with the wing frequency, thus obtaining a single standing image, and reads the figures from the dial. Reference to adjacent harmonics quickly settles any doubt as to whether one has been observing the true fundamental or one of its submultiples.

Because of the natural variation in rate, it is often difficult to retain a standing image over any extended period, though

constant frequency over an interval as long as one minute has been observed not infrequently in *Drosophila*. In determining rates, this is again of no particular disadvantage in most cases, for here the limits of variation are the significant feature and may be measured quite accurately. Where observations of wing motion as such are to be made, however, it is of importance to know whether or not the apparent motion has the same sign as the true motion. For example, the wings of a noctuid moth during the downstroke show a marked upward curvature of the flexible tips. If the stroboscope be tuned to a frequency slightly above that of the wings, there will be a slow apparent motion in reverse of the true motion, and the wing tip will then *seem* to be bent upward during the upstroke. Such incongruities may be less patent in the motions of a smaller or more stiff-winged insect, so that caution is necessary. This is particularly so of insects with a very variable rate, whose true frequency may be now to one side and now to the other of the setting on the dial.

Transient motions, for example those involved in starting or in stopping flight, are beyond the scope of such a method. Here, as in many other instances, the ultimate recourse must be the motion-picture camera.

A further weakness of the instruments obtainable at present is that the intensity of the neon bulb is rather low. This means that specimens must be placed close to the source, and outside illumination cut off or reduced to a minimum. In theory it should be quite possible to observe with stroboscopic light the motions of an insect flying freely in a room; practically this ideal is difficult to attain. Even with completely adequate lighting such methods could not be satisfactory with the smaller species. With larger forms, of the size of *Leucania unipuncta* Haw., for instance, they may be useful, once the essential improvements have been made.

With the cooperation of Professor Edgerton, of the Massachusetts Institute of Technology, the writer has been supplied with additional equipment, including tubes of higher intensity. These give a bluish-white light which is suitable for certain types of photographic work. Photography with the neon tubes is out of the question. Unfortunately the bluish-white light seems to have an inhibitory

effect upon many insects, so that these tubes have not been as useful in the study of free flight as had been hoped. Whether this is due to some peculiarity of the spectrum, or to an effect of flicker at the higher intensities, which is lacking with the neon bulb, has not been determined. Certain moths are sensitive to noise, and respond adversely to the high-voltage crackle from these tubes as well as to the quality of the light. Still it has been possible to take readings on the wing rate of these and other insects flying freely in a room 12' x 15', and observations on specimens confined in jars and other containers are often productive. The brighter bulbs have also been used to advantage in studying specimens held in fixed position. At present it is not possible to obtain tubes of this sort which will operate at frequencies much above 100 per second. In connection with the problem of lighting, it may be remarked that, no matter how perfect it may be made, there will always be the natural variation in wing frequency to deal with, as well as the limitation set by what the human eye can observe in a small object traveling rapidly through space.

Where specimens held in fixed position are to be studied, the technique of fastening them is important. A discussion of the problems this introduces would lead beyond the limits of this article, and must be deferred to another occasion.

Finally, one additional limitation of the stroboscopic method should be noted. At rates well below the fusion frequency for the human eye, there is, as might be expected, a disagreeable flicker. This is especially objectionable when one is observing through the binoculars. Fortunately the wing rate of most insects is high enough so that this drawback is of minor consequence. The writer finds observation not uncomfortable at frequencies as low as 20 or 25 per second, where detail, such as motions of parts of the thorax, is to be studied. Direct rate readings are possible down to the limit of 10 per second, or may be taken in higher multiples if this seems preferable.

In concluding this criticism of the stroboscopic method, one may point again to the great advantage of being able to make direct visual observation of the motions of flight, at a rate determined by the observer, and also to the large number of observations that can be made within a limited time.

It is quite practicable to take a series of rate readings on one individual at 10-second intervals. With a series of specimens, where one observer has done all the handling and recording, the interval between readings has been about 40 or 50 seconds; if the recording is done by a second person, rates may be read on several specimens within a minute.

It is felt that a great deal can be added to our knowledge of insect flight by the more extended use of this type of stroboscope. Much that is now conjectural in regard to the motions of the wings can be replaced by fact, easily and at relatively small expense. Even after high-speed photography has reached the state of perfection desired, and the day is not yet, the stroboscope will still have its own field of usefulness. There is need for extensive observation of living specimens under experimental conditions where photography may be neither necessary nor possible. For the photographer himself the stroboscope is a valuable adjunct which permits him to study in advance the rate and type of motion which he is about to attempt to photograph. The various shortcomings and difficulties to which attention has been called above are those which have presented themselves during six months work with this instrument on the problems of insect flight and should serve to indicate the natural limitations of the method.

The application of the stroboscope in the study of wing motion has been simplified by the generous cooperation of Professor H. E. Edgerton of the Massachusetts Institute of Technology. The writer wishes to take this opportunity of acknowledging his assistance and of thanking Professors C. T. Brues and A. C. Redfield, of the Department of Biology, Harvard University, for their encouragement in this work.

LIST OF REFERENCES CITED.

- Germeshausen, K. J. & Edgerton, H. E. 1937. The Strobotron. *Electronics* 10 No. 2: 12, Feb. 1937.
- Landois, H. 1867. Die Ton- und Stimmapparate der Insekten in anatomisch-physiologischer und akustischer Beziehung. *Z. wiss. Zool.* 17: 105-184, 187.
- Magnan, A. 1934. La locomotion chez les animaux I. Le vol des insectes. Paris, Hermann & Cie., 1934.
- Marey, E.-J. 1868. Déterminations expérimentales du mouvement des ailes des insectes pendant le vol. *C. R. Acad. Sci. Paris*, 67: 1341.

- Oehmichen, E. 1920. Nos maîtres les oiseaux. Étude sur le vol animal. Paris, Dunod, 1920.
- Pettigrew, J. B. 1868. On the mechanical appliances by which flight is attained in the animal kingdom. Trans. Linn. Soc. London, 26: 197.
- Prochnow, O. 1924. Mechanik des Insektenfluges. In Schröder, Chr., Handbuch der Entomologie Bd. I, Jena, 1928.
- Snodgrass, R. E. 1935. Principles of Insect Morphology. New York, 1935.
- Stellwaag, F. 1916. Wie steuern die Insekten während des Fluges? Biol. Zbl. 36: 30.
- Weber, H. 1933. Lehrbuch der Entomologie. Jena, 1933.
- Wheatstone, Sir Charles. 1827. Description of the Kaleidophone, etc. Quart. J. Sci. Lit. Art. 1: 21.

IMMATURE NORTH AMERICAN TRICHOPTERA

BY MARGERY J. MILNE

Randolph-Macon Woman's College,
Lynchburg, Va.

Several keys to the larvæ and two to the pupæ of North American Trichoptera are already available¹ but none of them summarizes recent study of adequate material, and all but one are based either directly or indirectly on tables presented by European workers.

A search for family and subfamily characters in North American caddis larvæ and pupæ has yielded the two keys below. Since the pupal stage is much less completely known than the larval, the key to the former is more artificial than that to the latter, especially with respect to members of the families Odontoceridæ and Sericostomatidæ. To somewhat offset this disadvantage, a very useful list of spur formulæ is appended, summarizing the known information on this character.

- ¹1901. Betten, C. in Bull. 47, N. Y. State Mus. pp. 563-564. A larval key compiled from European papers by Klapalek and Struck.
1915. Krafka, J. Jr. in Can. Ent. 46: 217-225. Original keys to larvæ, guided by Ulmer's 1909 European work.
1921. Lloyd, J. T. in Bull. 21, Lloyd Lib. (Ent. Ser. 1) p. 15. A slightly modified translation of Ulmer's 1909 key, larvæ only.
1921. Lutz, F. E. in Field Book of Insects (Putnam) pp. 58-60. A modification of Betten's 1901 key to larvæ.
1925. Comstock, J. H. in Introduction to Entomology (Comstock) p. 560. A modification of Lloyd's 1921 key to larvæ.
1926. Essig, E. O. in Insects of Western North America (Macmillan) p. 175. A modification of the key to larvæ in Lloyd 1921 and Comstock 1925.
1926. Sibley, C. K. in Bull. 27, Lloyd Lib. (Ent. Ser. 5). An apparently original key to the pupæ of species found on the Lloyd-Cornell Reservation, N. Y.
1933. Brues, C. T. & A. L. Melander in Bull. 73, Mus. Comp. Zool. Harvard, pp. 195-197. A modification of Krafka's 1915 key to larvæ.
1934. Betten, C. in Bull. 292, N. Y. State Mus. pp. 117-123, the larval key a copy of Krafka's 1915 work, the pupal key from Ulmer's 1909 key.

Caddis larvæ inhabiting movable cases have the head bent downward so that the mandibles are ventral (hypognathous) in position, the long axis of the head at an obtuse or even a right angle with the long axis of the body. Those with a right-angled attachment are said to be *eruciform* larvæ, those with an obtuse angle to be *suberuciform*. Caseless larvæ have the long axis of the head in line with the long axis of the body and the jaws hence at the anterior end of the animal (prognathous). Such larvæ are said to be *thysanuriform* or *campodeiform*.

Case-bearing larvæ frequently have fleshy tubercles on the sides and notum of the first abdominal segment. These are called *spacing humps*, and serve to keep a passage for respiratory water between the larva and its case. Such larvæ also often have a prominent projection from the prosternum, extending between the front coxæ. This is the *prosternal horn* or *prosternal spine*.

The head capsule or *epicranium* splits at ecdysis into right and left halves. It bears the articulating surfaces for the mandibles antero-laterally and may or may not meet on the mid-line ventrally, anterior to the neck opening (*occipital foramen*). In some forms a submentum or *gula* is well developed, the gula being sometimes quadrate, at other times triangular or crescentic. It may keep the epicranial halves entirely apart, extending from the labium to the occipital foramen, or it may separate them only anteriorly, so that the foramen is entirely surrounded by epicranium. A U- or V-shaped emargination in the anterior margin of the epicranium on the mid-dorsal line accommodates the *frons* to which the *labrum* is attached by a flexible membrane. There is no clypeus. The antennae are usually very small.

Many larvæ have a fringe of hairs along the abdominal lateral line, the so-called "*lateral fringe*." The abdomen frequently bears along the dorsal, lateral and ventral surfaces filamentous or branched structures called *gills*, although their respiratory function is doubtful. Around the anus filamentous or sac-like structures are often seen. These are the *rectal gills*, which are seemingly retractible into the rectum. Also apical on the abdomen are the *prolegs*, fleshy structures with claws, used in locomotion. The thoracic appendages are true *legs*, and consist of five segments, a

large *coxa* articulating with the pleurite, a small trochanter (always indistinctly divided), a large *femur*, a *tibia*, and a one-segmented *tarsus* bearing a movable *claw*. Usually the tibia ends in a spur. In Leptoceridæ and some Odontoceridæ, the middle and hind legs have the *femora* divided into two, the proximal half shorter than, or equalling the distal half.

In the pupæ imaginal structures such as antennæ, maxillary and labial palpi, ocelli, tibial spurs, sternal ligulæ and genitalia may be studied, in addition to the labral bristles, gills and anal processes of the pupal skin itself. All females have the *maxillary palpi* 5-segmented, but the males of some families show a reduction in this number. In some families in which both sexes have 5-segmented maxillary palpi, the terminal segment is secondarily annulated. *Labial palpi* are always 3-segmented. There are 3 *ocelli* present or none are found. The fore tibiæ may have as many as 3 spurs, the middle and hind tibiæ as many as 4 spurs. When no more than 2 spurs are present, they are terminal. A third or fourth spur is added part way up the tibia. The number of spurs is indicated by a *spur formula*. Thus 1-3-4 indicates that the fore tibia bears one (terminal) spur, the middle tibia a pair of terminal and a subapical spur(s), the hind tibia a pair of terminal and a pair of subapical spurs. The *labral bristles* are used to clean the gratings which allow entrance of water into the pupal case. The *gills* are much like those of the larva but often differ in number and arrangement. The *anal* processes are extensions of the pupal skin which cover the cerci and genitalia and often bear bristles for cleaning the grating which allows exit of water from the pupal case.

KEY TO NORTH AMERICAN CADDIS LARVÆ

1. Abdomen very much wider than thorax; very minute species with all three thoracic segments heavily sclerotized above, living in portable silken cases which are much larger than the larvæ: *Hydroptilidæ*

Abdomen not much wider than thorax; much larger species, never with all three thoracic nota heavily sclerotized above in any case-bearing species, the cases when present not much larger than the larvæ 2

2. Last abdominal segment never with a sclerotized shield above; body campodeiform, the head held straight forward, forming a continuation of the long axis of the body; abdomen of nine segments, the prolegs distinct from one another; no tubercle on first abdominal segment; no prosternal horn; no lateral line fringe; abdomen depressed, the sutures between the segments deeply impressed; gills usually absent; rectal gill structures generally present but not always everted; larvæ not constructing a movable case 3
 - Last abdominal segment usually with a sclerotized shield above—if lacking it, the body eruciform (hypognathous) and the larva living in a movable case (Leptoceridæ); gills usually present 10
3. Labrum soft, whitish, retractile under edge of frons 4
 - Labrum wholly sclerotized 5
4. Mandible with a prominent tooth at middle of medial margin; frons with a deep asymmetric emargination: *Philopotamidæ*, subfamily *Chimarrhinæ*
 - Mandible with no such prominent tooth; frons scarcely emarginate:
 - *Philopotamidæ*, subfamily *Philopotaminæ*
5. Claws of legs long and slender, nearly straight, with only one basal spur; penultimate segment of maxillary palpus very long:
 - *Psychomyiidæ*, subfamily *Polycentropodinæ*
 - Claws of legs short, stout, curved; penultimate segment of maxillary palpi not especially long 6
6. Gills absent; only two bristles on convex side of mandibles 7
 - Gills present; numerous bristles on convex outer side of mandibles; all three thoracic nota sclerotized 8
7. Only prothorax sclerotized dorsally:
 - *Psychomyiidæ*, subfamily *Psychomyiinæ*
 - All three thoracic nota sclerotized:
 - *Psychomyiidæ*, subfamily *Ecnominæ*
8. Gula an elongate, rectangular plate separating epicranial halves completely; all gill filaments in clus-

ters arising from the ends of stalks, somewhat like the tentacles of Hydra; large forms:

..... *Hydropsychidæ*, subfamily *Arctopsychinæ*

Gula triangular, never reaching hind margin of head, the epicranial halves contiguous for some distance; gill filaments arising from the side as well as the end of the stalk, more comb-like 9

9. Dorsal surface of head flattened, forming a broad disc, enclosed by a strong carina which crosses the frons near its apex, setting off a small triangle; mandibles with broad, blunt teeth on whole inner margin, the interspaces broad and deep:

..... *Hydropsychidæ*, subfamily *Macronematinæ*

Dorsal surface of the head flattened, but with no carina defining its limits; mandibles with sharp teeth apically: *Hydropsychidæ*, subfamily *Hydropsychinæ*

10. Body campodeiform, the abdomen depressed; larvæ never constructing a movable case though sometimes building a fixed shelter 11

Body eruciform or suberuciform, the head bent downwards at an angle to the rest of the body; abdomen cylindrical, the sutures between the segments usually feebly impressed; gills usually present; larvæ always living in a movable, tubular shelter 12

11. Prolegs very well developed, entirely separate from each other; proleg claws long and slender, without teeth on convex surface; accessory claws sometimes present at sides of main proleg claws; maxillary lobes long and slender:

..... *Rhyacophilidæ*, subfamily *Rhyacophilinæ*

Prolegs short, the basal segments wholly sclerotized and fused to the ninth abdominal segment in a nearly vertical position; proleg claws very short, with small teeth on the convex side; maxillary lobes short and broad; construction of a fixed shelter in late larval life is usual:

..... *Rhyacophilidæ*, subfamily *Glossosomatinae*

12. Prosternum with a horn or spine projecting downwards between the front coxæ 13

- No such prosternal horn 15
13. Body suberuciform; lateral gills on segments 2 to 7 usually pubescent with black hairs; mesonotum generally soft like metanotum, rarely with two small sclerotized plates; abdominal constrictions well marked: *Phryganeidæ*
- Body eruciform; lateral gills on segments 2 to 7 never pubescent with black hairs; mesonotum generally entirely sclerotized, sometimes only with small plates, rarely completely soft 14
14. Mesonotum entirely sclerotized; metanotum with three pairs of plates; mesothoracic legs stouter and longer than hind legs: *Limnephilidæ*
- Mesonotum not entirely sclerotized; metanotum usually entirely soft; middle legs not longer than hind legs: A few *Sericostomatidæ* (Goerinæ & Lepidostomatinae)
15. Femora of middle and hind legs divided into a shorter basal and a longer apical piece; right mandibles without inner bristles; no accessory bristles on back of mandibles: 16
- Femora not divided 17
16. Lateral line well developed 17
- Lateral line little developed or absent: *Leptoceridæ*
17. Lateral line well developed, the 8th segment never with only sclerotized points representing the line; labrum with a transverse row of many stout bristles before the middle, or if lacking these, then much longer than broad: *Odontoceridæ*
- Lateral line very faint, incomplete or absent, its place sometimes occupied on some segments by sclerotized points; labrum neither with a transverse row of bristles nor longer than broad 18
18. Antennæ rudimentary; pronotum sclerotized, mesonotum never more than partially sclerotized: *Sericostomatidæ*
- Antennæ large, the basal segment broad, 2nd more slender and tipped with a fine bristle; pro- and mesonotum both sclerotized 19

19. Distal spurs of fore and middle tibiæ not on prominences; hind legs with normal claws; cases curved tubes, never broad: *Beræidæ*
 Distal spurs of fore and middle tibiæ on prominences; claws of hind legs abnormal; cases of sand, broadly shield-shaped like a turtle shell, except those of very young larvæ which have straight sand tubes, often with bits of mollusk shells: *Molannidæ*

KEY TO NORTH AMERICAN CADDIS PUPAE

1. Pupæ very small (not more than 5 mm. long, usually less than 3.5 mm.), with very short thick antennæ; maxillary palpi 5-segmented in both sexes; cases mostly of silk only or of silk covered with very fine sand, the cases flat or thickest in the middle, usually attached at each end by circular discs of silk:
 *Hydroptilidæ*
 Pupæ usually larger, the antennæ nearly as long as the body, not especially thickened; maxillary palpi sometimes 3- or 4-segmented in the male; cases never as above 2
2. Lacking both ocelli and a complete tubular case 3
 Either ocelli or a complete tubular case or both present 5
3. Gills absent:
 *Psychomyidæ*, subfamily *Psychomyiinæ*
 Gills present 4
4. Spurs 3-4-4; anal processes large, blunt, not long; cases made of pieces of leaves or small sand grains, the ventral side of silk only (in *Phylocentropus* the case is a long, branched tube of sand with only a turret projecting; in *Neureclipsis* the case is a trumpet-shaped net);
 *Psychomyidæ*, subfamily *Polycentropodinæ*
 Spurs 2-4-4 or fore tibiæ with one or no spur; anal processes long and heavily sclerotized, with many bristles: *Hydropsychidæ*
5. Case complete, the pupa never in an inner silken cocoon; gills often present; anal processes often long,

- rod-like and strongly sclerotized; legs with or without claws 9
- Case incomplete, the pupa in an inner silken cocoon; gills absent; no long or rod-like or strongly sclerotized anal processes; legs with good claws 6
6. Inner silken cocoon spindle-shaped like a zeppelin or a fly puparium, attached to the case only at its posterior end; case barn-shaped, usually of pebbles; 5th segment of maxillary palpi not annulated 7
- Inner silken cocoon either not complete or fused to case wall near its equator; when incomplete, the anterior end lacking, the posterior end much as in *Rhyacophilinæ*; 5th segment of maxillary palpi long, curved and distinctly annulated 8
7. Spurs 2-4-4: *Rhyacophilidæ*,
subfamilies *Glossosomatinae* & *Hydrobiosinae*
Spurs 3-4-4: *Rhyacophilidæ*, subfamily *Rhyacophilinae*
8. Spurs 2-4-4: *Philopotamidæ*, subfamily *Philopotaminae*
Spurs 1-4-4: *Philopotamidæ*, subfamily *Chimarrhinae*
9. Ocelli present 10
Ocelli absent 12
10. Posterior margin of 1st abdominal tergite produced caudad in a distinct median process extending over base of 2nd segment; mandibles with a prominence from which the bristles arise; anal processes flat, somewhat rhombic, with 4 long bristles at the end; spurs 2-4-4; male maxillary palpi 4-segmented: *Phryganeidæ*
- Posterior margin of 1st abdominal tergite not produced caudad but with a saddle-shaped prominence, laterally with short spines or with only two lateral tubercles set with numerous hairs or denticles; mandibles with no such prominence; never more than one protibial spur; male maxillary palpi 3-segmented; anal processes long, more slender 11
11. Labrum semicircular, anteriorly emarginate, the dorsal surface elevated, with a transverse furrow back of its mid line; spurs 1-1-1, 1-2-2, 1-2-3, 1-2-4, 1-3-3 or in most, 1-3-4: *Limnephilidæ*

	Labrum roughly rectangular, the anterior margin formed of 3 curves, in each of the two emarginations of which is a fine bristle; 5 longer bristles with curved tips vertically on either side of labrum; spurs 1-2-4 (Pharula) or 1-3-4 (Neothremma):	.....
	.....	<i>Sericostomatidæ</i> , subfamily <i>Georinæ</i> in part
12.	Antennæ very long, the outer part wound around the abdominal apex	 13
	Antennæ scarcely longer than body, the ends never wound as above	 14
13.	Two mesotibial spurs; mouthparts so placed that the pupal mandibles point upwards:	 <i>Leptoceridæ</i>
	Four mesotibial spurs; mouthparts normal or as above:	 some <i>Odontoceridæ</i>
14.	Spurs 2-2-2 (Micrasema) or 2-3-2 or 2-3-3 (Brachycentrus); labrum obtusely triangular to semicircular; maxillary palpi shorter than or but little longer than labial palpi, never stouter:	.....
	.....	<i>Sericostomatidæ</i> , subfamily <i>Brachycentrinæ</i>
	Spurs not as above	 15
15.	Case shaped like a snail shell, coiled in a flat spiral, made of sand grains of small size:	.....
	.....	<i>Sericostomatidæ</i> , subfamily <i>Helicopsychinæ</i>
	Case never of this form	 16
16.	Less than four mesotibial spurs	 17
	Four mesotibial spurs	 18
17.	Body length not less than 5 mm.; robust species:	.....
	.....	<i>Sericostomatidæ</i> , subfamily <i>Sericostomatinaæ</i>
	Body length not over 4 mm.; slender, small species:	.....
	.....	<i>Beræidæ</i>
18.	Less than 4 metatibial spurs:	 some <i>Odontoceridæ</i>
	Four metatibial spurs, the formula 2-4-4	 19
19.	Anal processes lobate:	.....
	.....	<i>Sericostomatidæ</i> , subfamily <i>Lepidostomatinaæ</i>
	Anal processes rod-like	 20
20.	Case of sand, flattened dorso-ventrally and with lateral flanges, closed by discs of silk at the ends, that at the posterior end having a vertical slit, that at the anterior end a horizontal slit:	 <i>Molannidæ</i>

- Case not as above, and differently closed 21
21. Case of stones with ballast rocks at the side, straight,
never curved:
..... *Sericostomatidæ*, subfamily *Goerinæ* in part
- Not as above; case with a definite curvature:
..... some *Odontoceridæ*

In families Hydropsychidæ (with subfamilies Hydro-psychinæ, Arctopsychinæ and Macronematinæ), Psycho-myiidæ (with subfamilies Psychomyiinæ, Polycentropodinæ and Ecnominæ) and Philopotamidæ (with subfamilies Philopotaminæ and Chimarrhinæ), the 5th segment of the maxillary palpi is secondarily segmented in the pupa and adult. In Leptoceridæ it is long and slender and often curved but never segmented. In males of Phryganeidæ, the fifth segment is lacking, so that the maxillary palpi are 4-segmented; in males of Limnephilidæ (with subfamilies Apataniinæ and Limnephilinæ) and Sericostomatidæ (with subfamilies Brachycentrinæ, Helicopsychinæ, Lepidostomatinae, Goerinæ and Sericostomatinae) the 4th and 5th segments are lacking so that the palpi are 3-segmented. The females of these families and both sexes of families Hydroptilidæ, Rhyacophilidæ (with subfamilies Rhyacophilinæ, Hydrobiosinæ, Glossosomatinae), Beræidæ, Molannidæ and Odontoceridæ (with subfamilies Odontocerinæ and Calamoceratinae) have five segments to the maxillary palpi. In all Limnephilidæ, Philopotamidæ, Phryganeidæ, Rhyacophilidæ, two genera of Sericostomatidæ (Thremma and Neothremma of Goerinæ), and in six genera of Hydroptilidæ (Agraylea, Allotrichia, Ithytrichia, Neotrichia, Oxyethira, and Polytrichia) there are ocelli, but elsewhere they are lacking.

SPUR FORMULAE OF NORTH AMERICAN TRICHOPTERA

Formula	Family	Genera Concerned
0-2-2	Leptoceridæ	Leptocella, Leptocerus, Setodina, Ymymia
0-2-3	Hydroptilidæ	Neotrichia
0-2-4	Hydroptilidæ	Hydroptila
0-3-4	Hydroptilidæ	Agraylea, Allotrichia, Ithytrichia, Ortho- trichia and Polytrichia

Formula	Family	Genera Concerned
0-4-4	Hydropsychidæ	sometimes Hydropsyche
	Rhyacophilidæ	Protoptila
1-1-1	Limnephilidæ	Glyphopsyche (areolatus)
1-2-2	Leptoceridæ	Æcetis, Triaenodes, Ylodes
	Limnephilidæ	Apatidea (nigra), Chilostigma, Glyphopsyche (bellus, canadensis, irroratus, pritus), Homophylax (nevadensis), Ironoquia, Neophylax (fuscus), Stenophylax (subfasciatus), Zaporota
1-2-3	Limnephilidæ	Anabolina (litha, assimilis), Neophylax (ornatus)
1-2-4	Limnephilidæ	Anisogamus (antennatus), Apatidea (all but nigra), Ecclisomyia (all but simulata)
1-3-3	Limnephilidæ	Acronopsyche, Drusinus, Glyphopsyche (ullus), Halesochila, Oligophlebodes, Platycentropus, Stenophylax (circularis, dan, guttifer)
1-3-4	Limnephilidæ	all genera and species not indicated above
	Sericostomatidæ	Neothremma
1-4-4	Hydropsychidæ	sometimes Hydropsyche
	Philopotamidæ	Chimarrhinæ
	Sericostomatidæ	Pharula
2-2-2	Leptoceridæ	Athripsodes, Mystacides
	Sericostomatidæ	Micrasema
2-2-4	Beræidæ	all
	Sericostomatidæ	Helicopsyche, Sericostomatinae
2-3-2	Sericostomatidæ	some Brachycentrus
2-3-3	Sericostomatidæ	some Brachycentrus
2-4-2	Odontoceridæ	some Marilia, some Heteroplectron
2-4-3	Odontoceridæ	some Ganonema, some Notiomyia
2-4-4	Hydropsychidæ	Arctopsychinae, Hydropsychinae except some Hydropsyche
	Molannidæ	all
	Odontoceridæ	— some Ganonema, some Notiomyia, some Marilia, some Heteroplectron, all Namamyia, all Nerophilus
	Philopotamidæ	Philopotaminae
	Phryganeidæ	all
	Psychomyiidæ	Psychomyiinae
	Rhyacophilidæ	Glossosomatinae, Hydrobiosinae
	Sericostomatidæ	Goera, Pseudogoera, Lepidostomatinae
3-4-4	Psychomyiidæ	Polycentropodinae
	Rhyacophilidæ	Rhyacophilinae

THE MIMETIC RESEMBLANCE OF FLIES OF THE GENUS SYSTROPUS TO WASPS

BY CHARLES T. BRUES

Biological Laboratories, Harvard University

Together with a few relatives the genus *Systropus* is of very different appearance from the other members of the family Bombyliidæ to which it belongs. The body is extremely elongated and the dense pile that generally covers the body in the other, more or less thick-set bombyliids is so greatly reduced that the flies appear almost bare.

During a recent visit to the Dutch East Indies, I was fortunate in taking with the net two species of this genus on the island of Sumatra. Having previously observed and collected one of our common North American species, *Systropus macer* Loew, I was at once struck by the very different color pattern of its Sumatran relatives. Also the latter appear to mimic entirely different types of wasps, suggesting that two independent lines of evolution have been active in developing widely divergent, but equally fine cases of mimetic resemblance in the two hemispheres. This situation appeared so remarkable, that I attempted to follow it further by an inquiry into the color patterns of the other numerous members of the genus which is known to be almost world-wide in distribution. On account of their striking appearance and easy recognition a great many species have been described by a considerable number of entomologists.

Bezzi, in his taxonomic review of *Systropus* has already commented on the general color pattern which prevails among the species inhabiting two of the great zoological regions. He refers to the Oriental forms as having the aspect of vespids and the Nearctic ones as ammophiloid, *i.e.*, like the sphecoid genus "*Ammophila*" now called *Sphex* by taxonomists. The comparison is particularly apt in the case of the North American species as the resemblance to these digger-wasps is very great. Indeed, when in flight our com-

mon *Systropus macer* Loew may be readily mistaken for a species of "Ammophila", but it has the habit, frequently seen in dipterous mimics of wasps and bees, of resting on the leaves of plants even during the brightest hours of sunshine.

Among the Oriental and Indomalayan species the resemblance to vespid wasps is not nearly so close, but nevertheless very striking. In the case of *Systropus numeratus* de Meijere of which I collected a male at Bangkinan, Sumatra, during May 1937, it would appear that the model is *Stenogaster micans* Sauss.¹ as this wasp was flying very abundantly in the vicinity at the time the *Systropus* was taken. The two are of approximately the same size, but the gaster of the wasp is much stouter and the yellow markings on the thorax are larger, darker and do not coincide in size or position; likewise the wasp is brilliantly spotted on the sides of the gaster which is not the case in the fly. Nevertheless when alive the close resemblance is unmistakable although it is not borne out by a too critical comparison of the pinned specimens.

Another species, *Systropus varipes* Edwards, collected near Pematangsiantar, Sumatra is much smaller with darker legs and abdomen, and although quite wasp-like, is less conspicuously so and no vespids that resemble it at all closely were observed flying at the same time. Several of the small social species which are there common were present; all of these are much stouter and could not under any circumstances be confused with the *Systropus*.

In general, the species of *Systropus* in this part of the world are "vespoid" mainly by reason of a conspicuous spotting of the thorax which is marked with light yellow. Although the pattern varies, the basic arrangement of markings is of one type with permutations in shape and size. The coloration of the abdomen is black, varied with reddish brown or dull yellow, the reddish usually at the base and the yellow on the apical segments or venter.

In the Nearctic "ammophiloid" species the pale spotting of the thorax disappears and the reddish color is restricted to the petiolar basal segments of the abdomen while the

¹Kindly identified for me by Dr. Jos. Bequaert.

yellowish abdominal markings are lost. This coloration, in combination with the shape of the body produces the really astonishing resemblance between the fly and wasp, since most of our common "Ammophilas" have the conspicuous red basal abdominal marking.

The African species are in general colored like the Nearctic ones with the ferruginous color sometimes extending conspicuously on to the thorax, although pale spotted ones are known also from this continent.

Among the species known from the Neotropical region the thorax may be conspicuously marked with whitish or yellowish or this pale pattern may be almost entirely suppressed. They are thus intermediate between the "vespoid" and "ammophiloid" series.

A Tasmanian species, *S. clavifemoratus* Hardy is of the unspotted type and also one from Madagascar while *S. studyi* Enderlein from South China is said by its describer to resemble *Ammophila atripes*.

If then we consider the species from the several zoological regions together the development of two such divergent mimetic types is not so surprising for each appears to represent a modification of not such very great extent from a somewhat intermediate pattern. As the "ammophiloid" type is more widely distributed, extending even into the Australian region, we may consider the development of conspicuous yellowish spotting as the more recent pattern.

SOME EXTRACTS FROM THE HISTORY OF
ENTOMOLOGY IN CHINA

BY GAINES LIU

Biological Laboratories, Harvard University

The following extracts are of historical interest only. They are published here, not in the spirit of questioning the scholarship of those whose work I shall mention, but to render available some of the historical facts to those who might care to have them but who are handicapped by language difficulties. My point can be better explained by a very good instance. In a book, called *Chow Li*, one of the 13 Classics published long before the Christian era, we find a detailed account of a "Bureau of Entomology" which would be considered well organized even under our modern standard. Yet China is not even mentioned by Dr. L. O. Howard, one of the best known and the most respected entomologists of the world today, in his "History of Applied Entomology". It is very plain in this case that the whole trouble is due to an inability to consult Chinese literature. Later on I shall publish a note on this ancient "Bureau of Entomology". For the present I should like to add some information to supplement the following books, namely:

1. The Biological Control of Insects, by H. L. Sweetman, 1936.
2. The Insect Singers, by J. G. Myers, 1929.
3. Entomology, by J. A. Folsom and R. A. Wardle, 1934.

1. *The Biological Control of Insects — Earliest Record ca. 889-903.*

This book appeared in 1936. I ordered it last year when I was in China but the war came earlier than the book, and it was only lately that I had the pleasure of making the ac-

quaintance of this excellent work. On the first page, Dr. Sweetman writes as follows:

"The first written record we have of the movement of beneficial insects is that of Forskål (1775). He states that the date palms in Arabia were attacked by ants, which often destroyed the trees. The growers introduced colonies of predatory ants annually from the mountains and these controlled the pest species."

Dr. Sweetman is well aware of the practice of using ants in pest control in that part of the world, for immediately he writes that "the use of ants for the protection of orchards from insect pests is a practice of long standing in various Asiatic countries, and is still employed today". To this, based upon my personal field data, I quite agree and I can add a few more uses of the ants and some other forms of biological control of insects as practiced in my country. But what concerns us now is the "first written record". The following is a translation of a Chinese record.

"There are many kinds of ants in Lingnan (South China). Sometimes one finds that the ants are carried in a bag and sold on the market. The ants are yellow with long legs, larger than ordinary ants and live in a nest made from leaves and twigs. They are bought for the protection of the orange for it is said that without these ants most of these fruits would be wormy."

This record is contained in a book called *Ling Pio Lu Yi* or Wonders from South China by Liu Shun. There is no way to tell when this book was published. We know, however, that the author served as an army officer in Kwangtung during the reign of Tsao Chung of Tang (889-903) and the time must have been near the end of the 9th or the beginning of the 10th century. The same fact was mentioned in "Book on Tree Planting" by Yu Tsung Ben, a writer from the Yuan Dynasty (1280-1368). Thus Dr. Sweetman will be glad to know that the written records of insect control really go back much earlier. The ants in question were determined, according to the correspondence I have had with Prof. W. E. Hoffmann of Lingnan University, Canton, as *Ecophylla smaragdina* Fab. and were determined probably by the late Professor Wheeler. Today in Canton nests of these ants may be bought for about one silver dollar each.

2. *The Insect Singers* — "*Chu Ki*" is *Lycorma* not *Huechys*.

Although this book was published in 1929, I had not seen it until recently when I came to work on the cicadas I brought from China. Dr. Myers, the author, has given us a handy and readable book on the natural history of these insects. What interests me particularly are those occasions where he speaks on cicadas in China. Here it gives me the impression that, being unable to get at the original sources and consequently relying on what others have to say, Dr. Myers, in some cases, unfortunately subscribed as an innocent victim to those mistakes committed by others.

For instance on page 3 he states, "the mention of cicadas apparently does not occur until the authoritative edition, the Pen Ts'ao Kang Mu, of A.D. 1578." The author gives one the impression that the cicadas were not mentioned until 1578 while what he really means, if I interpret correctly, is that they were not mentioned in the Pen Ts'ao. In either case, however, if one is able to read Chinese he will find that this is not correct. He will discover, for instance, many references to these insects both in the Li Chi or Book of Rites and the Shih Ching or Book of Odes as these two Classics are respectively known in English. This would mean that the earliest mention occurs at least not later than 500 B.C. because these two Classics were connected in one way or another with Confucius (551-479 B.C.). In short, Dr. Myers has been entirely deceived by the Japanese version.

On page 23, Dr. Myers writes: "the cicada itself was labelled Tchen, while the nymph—the tettionetra or cicada mother, of the Greek—Tchen touy, i.e. the cicada with a skin which falls like that of a serpent." Here we have another mistake that can easily be rectified if one knows Chinese. Tchen touy is the shed skin. How it came to be interpreted as "nymph" is abstruse because "touy" means shed and the shed skin of cicada is the form generally mentioned as a drug in the Chinese pharmacopoeia.

That Chu ki is a *Lycorma* (*L. delicatula* White), a fulgorid common in north China, not *Huechys sanguinea* De Geer, has never been suspected ever since the day when Amyot created the genus *Huechys* in 1836. It was fully accepted

by Distant in his Monograph of Oriental Cicadidae (1892) and Dr. Myers of course could not avoid the pitfall. I know that chu ki is *Lycorma* but I had not associated chu ki with *Huechys* until I read Myers' book (p. 22), although I have always tried to identify *Huechys* in Chinese ever since I learned from Distant that this insect is employed by the Chinese as a drug. Now it is clear that *Huechys* is a direct romanization of the Chinese term chu ki.

There are several ways to prove that chu ki is *L. delicatula* and not *Huechys sanguinea*. "Ki" means a "fowl" and the general form of a *Lycorma* resembles a fowl while the form of a *Huechys* does not. On the other hand, *Huechys* is a southern species, and becomes rare as we approach the Yangtze valley. Among the large number of specimens collected, I have only a single specimen from Wuchang and another one from Ichang (two new records for this species) while all the old specimens in the Harvard collection came from south China. The case with *Lycorma* seems to be just reverse. Although *delicatula* is known as far south as India, it is not so common in the south as in the north, although the south has its own species. Now all the writers of the Chinese Pen Ts'ao were people from the north. It seems to be more reasonable to assume that the insect in question is a northern species instead of a southern one. But the best proof is found in the description of chu ki as it was given by various medical men and for this I submit the following translation.

"These insects are very common in Honan. They look like a moth but with the abdomen larger and the head and the legs blackish. There are two pairs of wings, the outer pair (tegmina) is grey while the inner pair (wings) is deep red, decorated with all five colors"—from Pen Ts'ao Yen Yi by Kio Chung Pi (1111-1116).¹

"The chu are the ill-smelling *Ailanthus* trees. The outer wings of the insects (chu ki) are greyish yellow while the inner ones are decorated with all five colors. They generally line up on the tree and by the late fall, deposit their eggs on the bark. The nymph has six legs, with wings (?) doubled and black and the head depressed and truncated in front."—From Pen Ts'ao Kang Mu by Li Shih Chen (1578).

¹This is the period with which the name of the author is connected.

The "greyish yellow" is very accurate for those specimens I have from Peiping. From these descriptions, it is evident that chu ki is *Lycorma* and not *Huechys*.² *Huechys*, the black cicada with a red head, is called "Er", according to Fang Yen, another Chinese Classic appearing long before the Christian era.

In closing I have one other statement to make for those who are interested in biological problems in ancient China. Based upon my personal experience, obtained in preparing a "History of Entomology in China", a work encouraged by Professor C. T. Brues and Dr. G. Sarton, I have found that the earlier Chinese as a whole were quite vague in their expression. Exactly the same term may mean entirely different things to different authors and sometimes it is very difficult to distinguish them unless one has as a general background some knowledge of the fauna and flora of the region whence the author came. Thus it is not even safe to trust the translation of those who know Chinese unless they are duly qualified from a biological standpoint.

3. *Entomology — Fireflies as Imperial Entertainment in China.*

The following paragraph from Folsom and Wardle, page 521, is very interesting to me.

"Annually the people of Gifu collect many thousands of fireflies which are sent to Tokio and on a certain night are liberated for the enjoyment of the emperor."

This paragraph is interesting to me because it reminds me of the following story about one of the romantic emperors of China.

"In the 12th year of Da Yeh (616), emperor Yang visited the Ching Hua Palace. Bushels of fireflies were collected by imperial order. In the evening, the Emperor and his courtiers went up the mountain. The fireflies were then released and the whole valley became immediately enlivened with the sparklings of these insects."—Sui Shu or Annals of the Dynasty of Sui.

²For detailed description of these two insects, see page 157 (*Huechys sanguinea* De Geer) and page 207 (*Lycorma delicatula* White) in Distant, Fauna British India, Rhynchota, Vol. 3, 1906.

Whether the Japanese custom was introduced from China, we do not know. Japan did send a large number of students to China during the Tang Dynasty (618-907). The fireflies are still one of the best evening entertainments the Chinese children have today. Mothers are generally requested by their children to save their empty egg-shells in which the youngsters house their catch and watch the flashing in the dark when they go to bed.

FURTHER NOTES ON CANNIBALISM AMONG
LARVÆ

BY V. G. DETHIER

Biological Laboratories, Harvard University

In a previous communication (Dethier, 1937) most of the reported cases of cannibalism among lepidopterous larvæ were discussed. Hunger and crowding, with thirst as a contributing cause were found to be the prime factors inducing this anomalous diet. This confirms the conclusions of Hering (1926) whose book was previously unavailable to the writer. The present notes offer further explanatory data pertaining to hunger and crowding as causes of a meat diet. The effects of such a diet and the ability of a phytophagous larva to survive on one are considered. Additional cases are also cited.

I

In an effort to understand more fully the various causes initiating cannibalism and the carnivorous habit in general among lepidopterous larvæ the following experiments were designed.

Two final instar larvæ of *Estigmene acrea* Drury and one last instar larva of *Isia isabella* A. & S. were placed in a dry jar approximately twenty inches in volume. Also placed in the jar were one pupating *E. acrea* larva from which the cocoon had been removed, a smaller arctiid in similar condition, and one freshly killed *I. isabella* larva which had been slit open longitudinally. The experimental animals had neither eaten nor drunk for four days. It was observed that they crawled ceaselessly around the bottom of the container exploring the surface with their antennæ and mouthparts. Some dry faeces when encountered were nibbled at slightly. No unusual behavior occurred until the slit carcass was encountered. Here the live animals immediately sucked up the body fluids. After a period of five minutes all three

experimentals were eating the tissues of the exposed larva. Next a decapitated *Encoptolophus sordidus* Burm. was placed in the jar. Its metathoracic legs were removed to prevent kicking. The grasshopper was investigated by the larvæ but no attack made upon it; however, when the carcass was slit open, the larvæ that chanced upon it started feeding almost immediately. The flesh, the eggs contained within the abdomen, and as much of the cuticle as was not too heavily sclerotized were eaten. At this stage the small pupating arctiid was also eaten by the *I. isabella*.

It can be seen from these observations that larvæ are more readily attacked and eaten when their tissues are exposed. It is to be expected that caterpillars would be more attracted to exposed tissues because there is a more concentrated odor arising from them than from an insect completely sheathed in cuticle. Also, there is no stimulation of the mouthparts by an unmutilated carcass. On the other hand, body juices exposed to the air may stimulate the mouthparts directly. Further there is the possibility that larvæ partaking of body juices are prompted to do so by thirst. An unmutilated carcass is attacked only when the larvæ reach such a degree of starvation that they bite frequently at near-by objects.

In order to ascertain the exact series of events occurring when an animal with cannibalistic or carnivorous tendencies approaches another larva, a single live naked noctuid larva was placed in the jar with one *E. acrea*. In the limited area the two frequently encountered each other. The *E. acrea* had reached the stage in which it bit at all objects encountered. When it endeavored to take several bites of the noctuid, however, the latter thrashed about vigorously. Although the arctiid stabbed viciously at its intended victim several times, it finally withdrew. The noctuid's cuticle had not been pierced. On numerous occasions the same process was repeated. Finally the noctuid was rendered more or less quiescent by the buffeting of the more active and aggressive arctiid. In this quiescent state, more or less bathed in its own regurgitated juices and those of its attacker, the noctuid was eaten. Undoubtedly this procedure takes place in most instances when one live insect is eaten by another. The higher percentage of cannibalism noted under crowded

conditions (Dethier, 1937) may be explained by the fact that chance meetings are more frequent. When similar conditions were reproduced in a cage twelve by sixteen inches, both animals eventually died of starvation.

While experiments with mutilated animals indicate that thirst may be one factor in inducing cannibalism, the following experiments demonstrate that hunger by itself is an important factor.

One *E. acrea* was kept in a moist atmosphere, given its fill of water, and presented with every opportunity to continue drinking. When given a mutilated larva of the same species the experimental animal began feeding almost immediately. Repetitions of this experiment prove that hunger as distinct from thirst is one factor in inducing a carnivorous diet.

The experimental animals never chose a diet of meat in preference to plants. Plant food was always accepted even after the larvæ had gorged themselves with meat. In three hours a single *E. acrea* consumed one *E. sordidus*, another consumed one entire *Gryllus assimilis* Fab., and an *I. isabella* consumed one full-grown larva of *Vanessa virginiensis* Drury. These three arctiids pupated and produced normal adults.

With regard, therefore, to the rôle played by hunger and crowding in causing cannibalism the following conclusions seem justified: First, the degree of hunger is of considerable importance. Larvæ in the initial stages of hunger are not readily induced to eat flesh unless stimulated probably by the odor of the body fluids and more certainly by direct contact with them. Larvæ in the final stages of starvation yet still active enough to crawl about do not require such an intense stimulation. Since animals in this condition habitually nibble at near-by objects, they eventually bite through the integument of an intact carcass or a quiescent animal. At this juncture they too are stimulated by the flesh within. An exceedingly active victim is not actually eaten till it has been rendered more or less quiescent although it may still be capable of considerable movement. Second, crowding facilitates the initiation of the events already mentioned as caused by hunger. In addition crowding induces attacks not prompted by hunger (Balduf, 1931; Dethier, 1937).

II

It was observed that relatively large blocks of tissue were present in the fæces of these carnivorous larvæ. In order to facilitate the examination of these tissues to determine what benefit the larvæ were deriving from their diet the fæces were preserved in alcohol, sectioned in paraffin, and stained with Delafield's hematoxylin and eosin.

Examination revealed that the tracheae as well as all other chitinous structures had passed through the alimentary canal completely untouched. This was to be expected since the occurrence of an enzyme acting upon chitin is very limited (Uvarov, 1928). Epithelium had been completely broken down. Relatively large blocks of muscle tissue were present in the fæces. These were recognizable as such; but digestion had been more or less complete, nothing remaining but a faint indication of the muscle fibers. No conclusion could be drawn concerning the fate of fat due to the histological procedure employed. Plant material from the gut of the victim was also present in the fæces. Serial sections revealed that cell walls in the majority of cases were intact although the entire contents had been removed. This is in accord with Biedermann's (1919) contention that all the active components of the digestive juice can diffuse through cell membranes.

In order to throw further light upon the situation, larvæ were tested for the presence of various digestive enzymes. Tests were adapted from Swingle's (1925), Wigglesworth's (1928), Cole's (1928), and Feigl's (1937) techniques. No attempt was made to conduct a differential analysis. Invertase and maltase were present. Neither lipase, lactase, nor amylase were detected. Amylase had been found occurring quite commonly, however (Dirks, 1922; Straus, 1909; Biedermann, 1911 and 1919). Lactase had been reported from some species. Proteases and glycogenase also occur (Uvarov, 1928). It is apparent from the standpoint of the enzymes found present by various workers that phytophagous larvæ are capable of digesting a meat diet. That both proteases and diastases occur in carnivorous insects and phytophagous insects alike is well known.

As seen by the examination of fæces most of the constituents of a meat diet were utilized. Furthermore, all the

dietary requirements for complete development are met by a meat diet. The above considerations coupled with the fact that phytophagous larvæ have been successfully raised to maturity on a meat diet refute the belief that a plant diet is necessary for the well-being of these larvæ.

III

The following additional reports of cannibalism and the carnivorous habit have been gleaned from the literature.¹ Most of them may be explained on the basis of the principles set forth above and in a previous paper.

Riley, Packard, and Thomas (1883) stated that *Laphygma frugiperda* A. & S. and *Cirphis unipuncta* Haw. resort to cannibalism to satisfy their hunger when migrating. Many individuals are killed in this manner. Aitken and Davidson (1890) reported *Ornithoptera minos* Cram. as eating its own pupæ when normal food was wanting. Witfield (1889) regarded *Papilio ajax* L. as showing more highly developed cannibalistic propensities than any other Papilionid larva of his acquaintance. Floersheim (1909) found, on the contrary, that this species exhibits such behavior only during a shortage of food and then not very readily, since of twenty individuals but two were lost by cannibalism although the food shortage was extreme. Sorhagen (1899) listed all the cases (about eighty) of cannibalism known to him at the time. Forbes (1905) also reported *L. frugiperda* as being cannibalistic in nature when migrating. *Thecla w-album* according to Tutt (1905-1906) is commonly supposed to leave its food in order to feast upon the newly-formed pupæ of its own species. Hering (1926) designated eighty-one species as "Mordraupen" of which nine cases had been reported as occurring in nature. This list is based on that of Sorhagen. Lommatzoch (1926) reported *Spilosoma lubricipeda* Esp. as eating a dead noctuid when its food supply had been exhausted. The report of Junglung (1930) that *Scopelosoma satellitia* L. resorted to coprophagy in captivity when food was lacking is interesting. Small larvæ

¹Berg's paper quoted in *Psyche* 44(4): 114, 1937 was also reviewed in *Kosmos, Zeit. f. einheitliche Weltanschauung auf Grund der Entwicklungslehre*, 3: 362-363, 1878.

of *Carpocapsa pomonella* L. when crowded exhibit cannibalism (Balduf, 1931). Buckstone (1938) recorded an instance in which the larvæ of *Pieris rapae* L. and ova of *P. brassicae* were confined in the same box. When the latter emerged, they ate the former although the enclosed cabbage leaves were still fresh.

With further regard to cannibalism under natural conditions I am grateful to Dr. H. G. Crawford of the Department of Agriculture, Canada for permission to quote from correspondence with departmental officers in the field.

During the summer of 1938 outbreaks of *Cirphis unipuncta* Haw. occurred but no cannibalism was observed. However, Mr. R. P. Gorham reported that larvæ under laboratory conditions fed on pupæ although they showed no interest in larvæ even when massed together in great numbers. The same officer noticed no cannibalism in *Nephelodes emmedonia* Cram. *Agrotis fennica* Tausch repeatedly attack one another in captivity. Mr. Gorham is of the opinion that most of our common garden cutworms are cannibalistic on pupæ in the laboratory. No cannibalism was observed in *Euxoa ochrogaster* Guen. or *Loxostege sticticalis* L. Mr. K. M. King and Mr. H. L. Seamans report that larger larvæ of *Agrotis orthogonia* Morr. attack smaller and weaker ones especially in the laboratory. *Chizagrotis auxiliaris* Grote according to Mr. Seamans is markedly cannibalistic under conditions of migration. When the advance of the larvæ is checked by some obstacle such as a furrow, the weaker larvæ are quickly attacked. Curiously enough larvæ which have been killed by poisoned bait are frequently eaten.

LITERATURE CITED

- Aitken, E. H. and Davidson, J., 1890. Notes on the larvæ and pupæ of some of the butterflies of the Bombay Presidency. J. Bombay Nat. Hist. Soc., 5:362.
- Balduf, W. V., 1931. Carnivorous moths and butterflies. Trans. Illinois State Acad. Sci., 24(2): 156-164.
- 1938. The rise of entomophagy among Lepidoptera. American Nat., 72: 358-379.
- Biedermann, W., 1911. Die Aufnahme, Verarbeitung und Assimilation der Nahrung. Pt. 9. Die Ernährung der Insekten. Winterstein, Handb. vergl. Physiol. 2(1): 726-902.
- 1919. Beiträge zur vergleichenden Physiologie VII and VIII. Pflügers Archiv f. die ges. Physiologie, 174: 358-425.

- Buckstone, A. A. W., 1938. *Pieris rapæ* a cannibal. Entomologist, 71(897): 34.
- Cole, S. W., 1928. Practical Physiological Chemistry. 8th ed., Baltimore.
- Dethier, V. G., 1937. Cannibalism among lepidopterous larvæ. Psyche, 44(4): 110-115.
- Dirks, E., 1922. Liefern die Malpighischen Gefäße Verdauungsekrete? Arch. f. Naturgesch., 4: 161-220.
- Feigl, F., 1937. Qualitative Analysis by Spot Tests, 314-316, N. Y.
- Floersheim, C., 1909. Larval habits of *Iphiclides ajax*. Ent. Rec., 21(5): 113-115.
- Forbes, S. A., 1905. 23d Report State Ent. Illinois, 82.
- Hering, M., 1926. Biologie der Schmetterlinge, 71-75, Berlin.
- Junglung, G., 1930. Ein Fall von Koprophagie (Kotfressen) bei *Scopelosoma satellitia* L. (Lep.). Ent. Zeit. Frankfurt a. M., 43: 57.
- Lommatzoch, W., 1926. Sonderbare Mordegelüste einer Raupe. Int. Ent. Zeit., 20: 232.
- Riley, C. V., Packard, A. S., and Thomas, C., 1883. Third Report of the U. S. Ent. Commission, 117.
- Sorhagen, L., 1899. Mordraupen. Illustr. Zeit. f. Ent., 4(4): 49-51, 4(6): 82-85, 4(9): 135-137.
- Straus, J., 1909. Über das Vorkommen einiger Kohlenhydratfermente bei Lepidopteren und Dipteren in verschiedenen Entwicklungsstadien. Zeit. f. Biol., 52(1-3): 95-106.
- Swingle, H. S., 1925. Digestive enzymes of an insect. Ohio J. Sci., 25(5): 209-218.
- Tutt, J. W., 1905-1906. British Lepidoptera, 8: 37, London.
- Uvarov, B. P., 1928. Insect nutrition and metabolism. A summary of the literature. Trans. London Ent. Soc., 76(2): 255-343.
- Wigglesworth, V. B., 1928. Digestion in the cockroach. III The digestion of proteins and fats. Biochem. J., 22(1): 150-161.
- Witfield, 1889. Scudder's Butterflies of the Eastern United States and Canada, 2: 1273.

ADDITIONAL RECORDS OF ONYCHOPHORA FROM THE ISLAND OF HAITI

BY CHARLES T. BRUES

Biological Laboratories, Harvard University

When he visited Haiti several years ago Dr. P. J. Darlington, of the Museum of Comparative Zoology, obtained specimens of Onychophora from a number of localities in the Republic of Haiti. These proved to represent five distinguishable forms of the genus *Peripatus* s. str. Two of these, *P. manni* Brues and *P. dominicæ* Pollard, var. *haitiensis* Brues had been previously described by the writer from material collected by Dr. Wm. M. Mann.¹

The other three are additional forms of *P. dominicæ* and were described as varieties by the writer from Dr. Darlington's material.²

Quite recently Dr. Austin H. Clark³ described another species belonging to the related genus *Macroperipatus* from Haiti as *M. insularis*. This augments the list of Haitian Onychophora to six, including two genera and three species, one of the latter with four named varieties.

Last autumn Dr. Darlington again visited Haiti, this time extending his investigations eastward into the north and central portions of the Dominican Republic. There he secured series of *Peripatus* at five additional localities.

An examination of these series shows them all to be referable to *P. dominicæ* Pollard, var. *basilensis* Brues previously known from Mount Basil in the northwestern part of the island.

The distribution of *basilensis* is thus greatly extended by this material as indicated below.

(1) Mt. Diego de Ocampo, Northern Range, Dominican Republic. 3500-4000 feet (July 1938). One specimen, quite typical, but with 30 pairs of legs instead of 28 as in the type.

(2) North slope of Loma Rucilla, Central Range, Domin-

¹Bull. Mus. Comp. Zool., vol. 54, pp. 519-521 (1913).

²Psyche, vol. 42, pp. 58-62 (1935).

³Proc. U. S. National Mus., vol. 85, No. 3027, p. 3 (1937).

ican Republic, about 8000 feet (June 1928). Six specimens with 27 pairs (four individuals) or 28 pairs of legs (two individuals).

(3) North of Loma Rucilla, Central Range, Dominican Republic, 6000-7000 feet (June 1938). Two large females, each with only 26 pairs of legs.

(4) Constanza, Central Range, Dominican Republic, 3000-4000 feet (August 1938). Eight specimens with 27-31 pairs of legs; one ♂ with 27 pairs, one with 29 pairs, four with 30 pairs and two with 31 pairs.

(5) Vic Valle Neuvo, southeast of Constanza, Central Range, about 7000 feet (August 1938). Two specimens, each with 28 pairs of legs.



Fig. 1. Outline map of Haiti showing the known distribution of Onychophora. 1, *Peripatus manni*; 2, *Peripatus dominicæ*, var. *haitiensis*; 3, *Peripatus dominicæ*, var. *darlingtoni*; 4, *Peripatus dominicæ*, var. *lachauxensis*; 5, *Peripatus dominicæ*, var. *basilensis*; 6, *Macroperipatus insularis*.

It thus appears that *Peripatus dominicæ* var. *basilensis* extends eastward from Mt. Basil into the Northern Range of Mountains and also into the Central Range. All of the specimens listed above are very similar to the types although many of them have more pairs of legs. However, the number apparently never reaches that present in what I have considered to be the nearest relative, var. *darlingtoni* Brues which is so far known only from well out on the southwestern peninsula on the Massif de la Hotte.

The accompanying outline map, kindly drawn for me by Mrs. A. S. O'Connor summarizes our present knowledge of the distribution of Onychophora on the island of Haiti.

ON THE GENUS ABARIS DEJ.
(COLEOPTERA; CARABIDÆ)

BY S. L. STRANEO
Parma, Italy

I have been trying for many months to secure typical examples of all of the known species of the genus *Abaris* Dej., for a revision of the genus. However, I have been unable to secure all of them, so I shall limit myself here to some notes on the genus.

Chaudoir in his notes on *Abaris* (Bull. Soc. Nat. Moscou XLVII, 1873, p. 97) has written: "*Abaris picipes et striolatus qui ont . . . les segments abdominaux sillonnés*"; but he was wrong, because Bates in the original description of *Abaris picipes* said, "*ventre haud sulcato*" and, "*there is no appearance of a transversal groove on the ventral segments*". He said also (Biologia Centrali-Americana, p. 85) that *Abaris picipes* Bates is really an *Abaris*, but he put the species with *Abaris striolata* Bates. In the Junk Catalogue, Csiki has omitted *Abaris striolata* Bates. This species, known to me only from description, has the claws of the tarsi pectinated (Bates, *l. c.*, p. 85) and the ventral segments grooved; owing to these characters, it should be inserted in the genus *Abaridius* Chaud. or in a new genus near *Abaris* and *Abaridius*.

Here follows the description of a new species found in the material sent to me by P. J. Darlington Jr. of the Museum of Comparative Zoölogy of Cambridge, Massachusetts.

***Abaris darlingtoni* n. sp. (fig. 1)**

Aeneous, lightly virescent, head and pronotum very shiny, elytra a little less nitid; antennae, legs, and mouth ferrugineous, joints 1-3 of antennae a little darker in the middle, femora and apex of mandibles darker, lateral margin of pronotum ferrugineous, last ventral segment at apex broadly flavous. Length: 5.5 mm.; max. lat. 2.1 mm.

Head very similar to that of *Abaris aenea* Dej.; large, smooth, neck evidently constricted, eyes large and convex, frontal foveæ moderately deep, short, rather united by a vague frontal impression behind clypeal suture.

Prothorax wide, sides gently rounded, lateral margin slightly explanate and moderately reflexed in basal half, median line very fine, interior basal foveæ rather deep, the exterior ones more superficial, with a few large punctures, and rugosities, not extended to lateral margin; anterior margin a little less wide than the head with the eyes; base distinctly wider than the anterior margin.



Fig. 1. *Abaris darlingtoni* n. sp.

Elytra oblongo-ovate, a little wider than the prothorax, one half longer than wide, with the greatest width before the middle; striæ strongly impressed, the scutellary one vestigial; third interstice a little less wide than the first and second together, with a single puncture behind the middle.

Underside smooth, metapisterna long, ventral segments not sulcate.

Claws of the tarsi finely pectinated; onychium with some fine setæ on the underside.

The microsculpture, invisible on the prothorax, on the elytra is rather faint and transversal.

Locality: Panama Canal Zone: Barro Colorado Island (Van Tyne and Darlington), 2 examples. Holotype in the

Museum of Comparative Zoölogy at Cambridge, Massachusetts (type no. 23,393) ; allotype in coll. Straneo.

This new species is closely allied to *Abaris aenea* Dej. and *notiophiloides* Bates by the lack of a scutellary stria and by the lateral margin of the pronotum distinctly reflexed near the basal angles. Compared with *A. aenea* Dej. the 3rd interstice of elytra is wider (nearly as wide as in *notiophiloides*) and the lateral margin is a little less reflexed near the base: compared with *A. notiophiloides* Bates, the legs are ferrugineous and the femora darker (in *notiophiloides*, flavo-testaceous) and the base of the pronotum is punctured only near the basal foveæ (in *notiophiloides*, also in the basal part of lateral margin).

KEY TO THE SPECIES OF THE GENUS ABARIS DEJ.

- (1) (8) No scutellary stria.
- (2) (7) Lateral margin of pronotum in the basal part wide and distinctly reflexed.
- (3) (4) Third interstice of elytra subequal to or only a little wider than second. *aenea* Dej.
- (4) (3) Third interstice of elytra distinctly wider than 2nd, about as wide as first and second together.
- (5) (6) Legs flavous; base of pronotum punctured, including the basal part of lateral margin.
..... *notiophiloides* Bates
- (6) (5) Legs ferrugineous red, femora darker; base of pronotum punctured only near basal foveae.
..... *darlingtoni* n. sp.
- (7) (2) Lateral margin of pronotum even near base narrow and not reflexed.
..... *aequinotialis* Chaud.
- (8) (1) Scutellary stria present and rather elongate.
- (9) (10) Size smaller (5-5.5 mm.). *basistriatus* Chaud.
- (10) (9) Size larger (6.5-8 mm.).
- (11) (12) External basal foveae of pronotum not distinct, because lateral margin is widely reflexed.
..... *robustulus* Tschit.

- (12) (11) External basal foveae of pronotum very distinct, lateral margin of the pronotum not reflexed (from description).
..... *bigenera* Bates & *picipes* Bates

I do not know these last species, and in the original description there are no useful differential characters, for *A. bigenera* is compared with *Pseudobaris substriatus* Chaud. which belongs to another genus.

I have to thank Mr. H. E. Andrewes and Dr. P. J. Darlington Jr. for the specimens kindly sent to me for examination, and my friend Dr. F. Capra for his help in connection with old descriptions.

PIN-LABELS IN MULTIPLES OF 1000, ALIKE

One Dollar Per Thousand

Smallest Type. Pure White Ledger Paper. Not over 4 Lines nor 30 Characters (13 to a line) Additional Characters, 3 cents each, in total and per line, per 1000. Trimmed so one cut makes a label.

C. V. BLACKBURN, 7 Emerson St., STONEHAM 80, MASS.

CAMBRIDGE ENTOMOLOGICAL CLUB

A regular meeting of the Club is held on the second Tuesday of each month (July, August and September excepted) at 7.45 p.m. in Room B-455, Biological Laboratories of Harvard University, Divinity Ave., Cambridge. Entomologists visiting Boston are cordially invited to attend.

WARD'S ENTOMOLOGICAL SERVICES

Entomological Supplies and Equipment

Carefully designed by professional entomologists. Material of high quality at low prices. Send for Supply Catalog No. 348.

Insect Preparations

Life Histories, Type Collections, Collections of Economic Insects and Biological Insect Collections. All specimens are accurately determined.

Insects for the Pest Collection

We have in stock over three hundred species of North American Insect Pests. Send for Price List No. 349.

Ward's Entomological Bulletin

A monthly publication sent free to all entomologists requesting it.

Information for the Beginner

Send for "Directions for Collecting and Preserving Insects" by Dr. A. B. Klots. A mine of useful information. Price 15 cents.

WARD'S NATURAL SCIENCE ESTABLISHMENT, Inc.

**P. O. Box 24, Beechwood Station
Rochester, N. Y., U. S. A.**

The Frank A. Ward Foundation of Natural Science of the University of Rochester

BACK VOLUMES OF PSYCHE

The Cambridge Entomological Club is able to offer for sale the following volumes of Psyche. Those not mentioned are entirely out of print.

Volumes 2, 3, 4, 5, 6, 7, 8, 9, 10, each covering a period of three years, \$5.00 each.

Volumes 12, 14, 17, each covering a single year, \$1.00 each.

Volumes 18, 19, 20, 21, 22, 23, 24, 25, 26, each covering a single year, \$1.50 each.

Volumes 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, each covering a single year, \$2.00.

Orders for 2 or more volumes subject to a discount of 10%.

Orders for 10 or more volumes subject to a discount of 20%.

A set of all the volumes available (40 in all) will be sold for \$81.00.

All orders should be addressed to

F. M. CARPENTER, Associate Editor of Psyche,
Biological Laboratories,
Harvard University,
Cambridge, Mass.